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MEDICAL SOCIETY

MARCH 1964 VOLUME XLI NUMBER 5

ENVIROMENTAL MEDICINE

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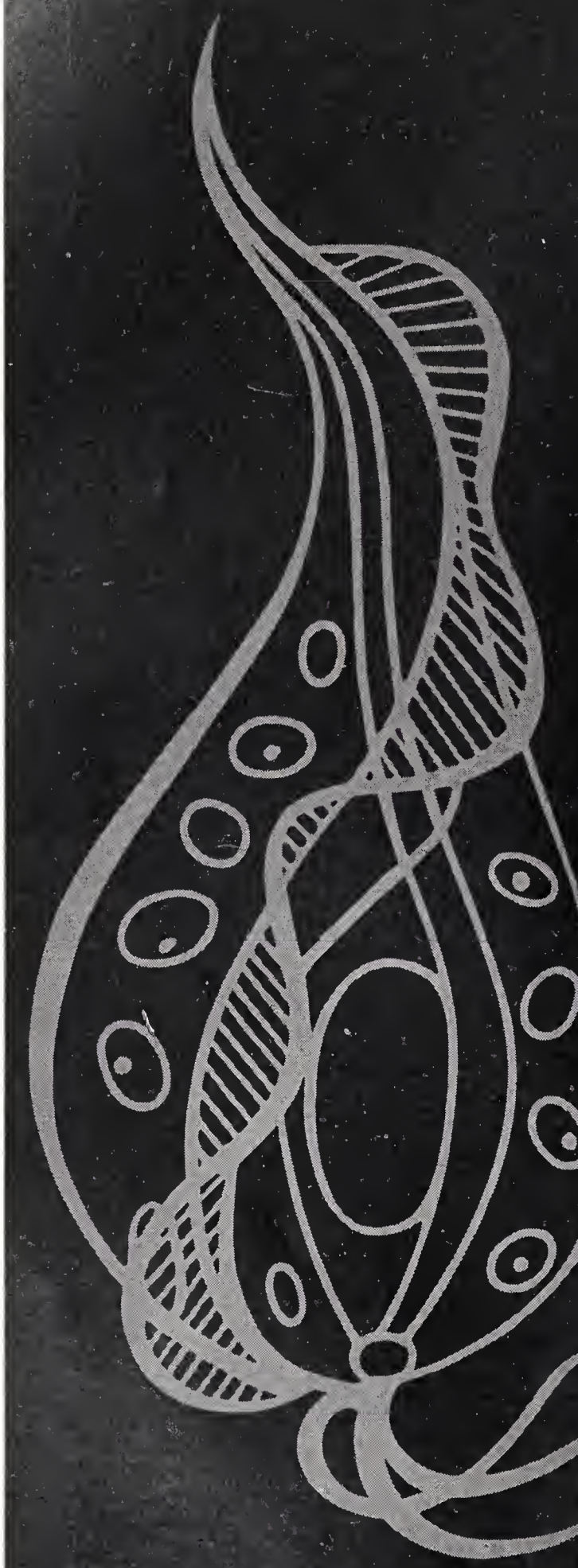

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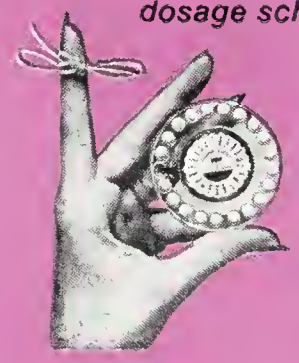

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Editorial

ENVIRONMENTAL MEDICINE

Adoption, modification of the immediate environment, suffering — these are the ways in which man has reacted to the harmful elements in his environment. There is no doubt that he has adopted to a considerable degree, and he has suffered a great deal too. But probably most important in the successful evolution and survival of modern man is his ability to alter his immediate environment.

Environmental medicine covers a wide spectrum of problems which arise from the unsuccessful interaction of man and his environment. Theoretically, the list of problems might include almost anything one might care to mention — infection diseases, neoplasm, as well as illness due to *excess physical forces*. However, for practical purposes only the problems related to physical forces — cold, heat, light, pressure, radiation — are included.

Man is by nature a curious animal. In earlier times, water and mountain and distant journeys represented a challenge in the unknown.

The simple fact of nature and survival along with this curiosity resulted in exploration and extension of man's immediate environment. It also resulted in diverse "unnatural and excessive" physical forces being weighed against him. To modify and control these forces was essential. The first fellow to warm himself by fire was undoubtedly a pretty sophisticated type in his day.

Thus man has progressed through the ages to the present nuclear and space age. He has the same curiosity, wetted by the past centuries of adventure and exploration. The problem of environment becomes more complex. The methods of controlling this immediate environment have been developed to a high degree. But, there is still failure and unsuccessful modification and so, the field of environmental medicine expands.

With more people being exposed by space travel to increasing affects of radiation — natural as well as man-made, the science of environmental medicine is becoming one of prevention.

The articles in the journal will present some facts about a selected few of the problems of environmental medicine, but more important, I hope they will stimulate some thought about this complex and expanding field.

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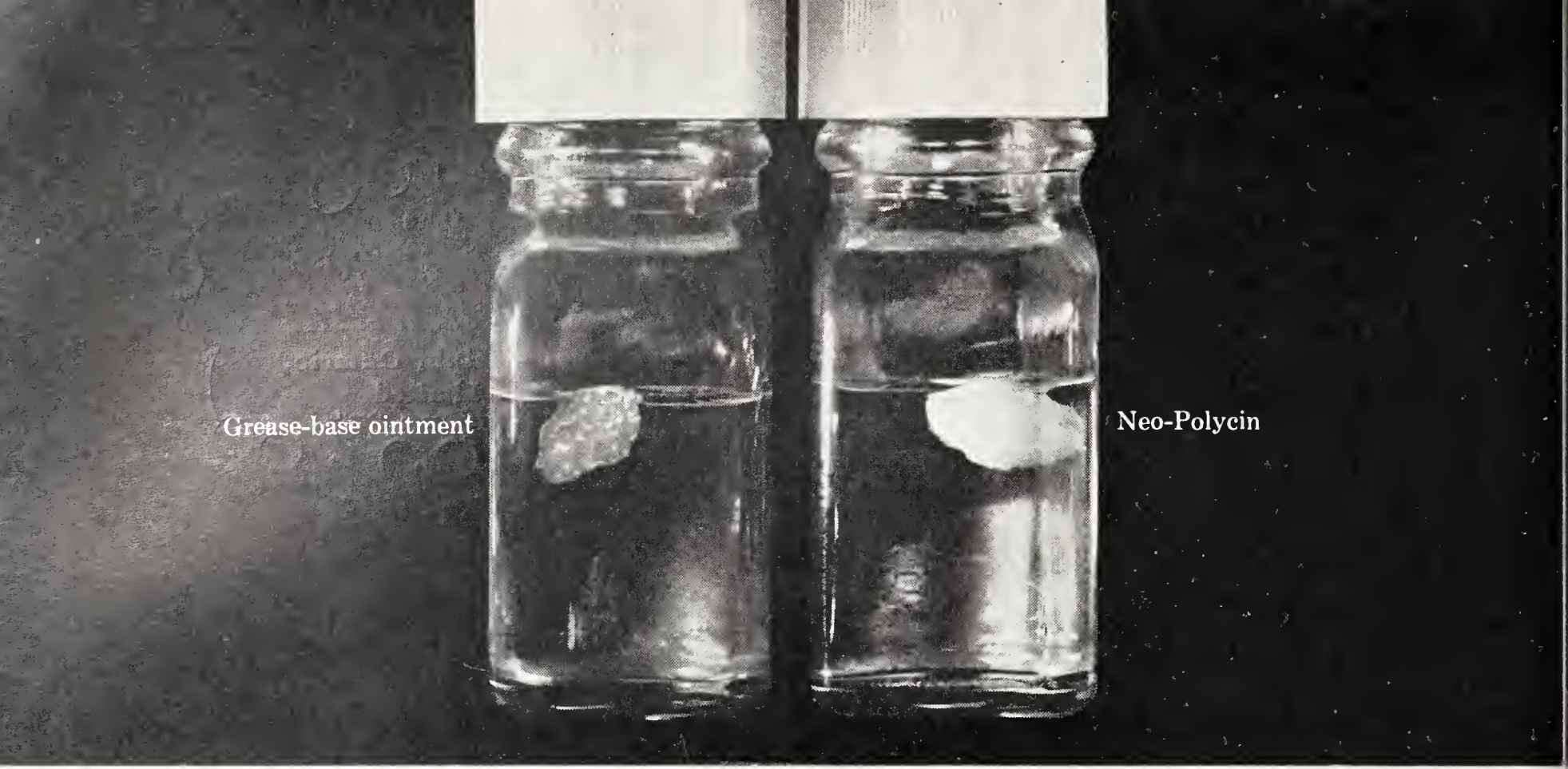

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Man and Exercise, A Review of the Effects of Physical Exertion

H. Armstrong B.P. & H.E., 6T4

I. *Introduction*

A list of the goals of modern civilization would include the diminuation of physical effort. The existence and prevalence of the automobile, the vacuum cleaner, the washing machine, the elevator, the automation of industry, and the electric tooth-brush attest to this fact. Human inventiveness, industry, and advertising have combined to make it possible for man to limit his daily toil to several hundred yards of slow walking. Machines and chemicals transport, wash, clothe, and exercise Western man without effort. Progress and muscle atrophy are our most important products.

Unfortunately, the easy life may not be the healthy life. Up to the present, there has accumulated a vast body of circumstantial evidence indicating this. In the acute phase of most illnesses, rest is necessary; however, with increasing frequency, both physical measures and exercise are proving necessary for speedy recovery from illness. Many disease states may be caused or contributed to by extreme inactivity[1]. It is incumbent upon the physician to know how much activity to prescribe in disease. It may become important to know how much activity and of what type to prescribe for the maintenance of health.

II. *Philosophical Considerations*

Today, medical science measures health only in the degrees of its absence. It divides Mankind into five categories; healthy, sick, sicker, moribund, and dead. As far as medicine is concerned, there is no such thing as *positive health;* yet, the idea that a healthy man might become healthier slipped into medicine many years ago when the concept of vaccination became universally accepted. Just as today's physician knows that inoculation may prevent some forms of infectious disease, thereby increasing health, it may be that tomorrow's physician will believe that physical fitness may prevent some forms of atrophic and degenerative disease.

From the dawn of man's history until the present century, man evolved in a physical environment. He was not equal to many members of the animal kingdom in strength, speed, or endurance, but these attributes played an important role in his survival. Up to forty per cent of a man's body weight is muscle[2], and the greatest feats of respiratory, cardiac, metabolic, structural, and haemodynamic performance come into play only during muscular activity. The physiology of man has evolved in an environment requiring his best physical performance.

Some of today's important medical problems may stem from these attempts to achieve an effortless existence. The world is full of back pain, mental illness, emotional and social problems, and constipated individuals who can find no outlet for tensions, frustration, and energy, other than being passively entertained. The fight-or-flight response is turned into peptic ulcer, neurocirculatory asthenia, and anxiety. Leisure time means restful relaxation time.

III. *Disease and Exercise*

Many conditions may be contributed to or caused by lack of exercise. Among these are obesity[1,3], back pain[1,4], contractures of joint disease[1,4], death from coronary disease[6,7,8], osteoporosis[9], dysmenorrhea[10], and many post-operative and post-bed-rest syndromes. Death from diabetes, peptic ulcer, appendicites, lung cancer, and prostatic disease are more frequent among the inactive[5]. Life insurance statistics show that individuals who are 35% overweight have a 137%-164% increase in mortality[1].

One pound of body fat contributes about 3,500 calories of energy. This would be used in about 60 hours at rest, in about 30 hours doing office work, and in about 3 hours running at 11.4 m.p.h.[3,11]. This means that one must run hard for more than 30 miles in order to lose 2 pounds — a seemingly superhuman task. Actually, this could easily be done by most fit people in 12 fifteen-minute periods distributed over 3 weeks. In 2 years at this pace, one would lose between 15 and 20 pounds. Year after year this alone would contribute greatly to weight control. However, as is well known, food intake is the key to weight control. Surprisingly enough, exercise does not produce excess appetite; instead it contributes to the stabilization of normal satiation levels. At low levels of exercise, appetite decreases and weight gain follows; at moderate levels of exer-

cise, appetite increases, but weight remains constant; at extreme levels of exercise, both weight and appetite decrease drastically[1].

It is well known that inactivity in rheumatoid arthritis and other forms of arthritis contributes greatly to disability and immobility. Physiotherapy, and exercise in particular, is one of the mainstays of treatment. Articular cartilage is thicker in exercised growing animals than in those kept at rest. Exercise increases both the amount and viscosity of synovial fluid and decreases hyaluronic acid concentration in joints. It is not surprising then that movement and weight-bearing are essential for healthy joints[3,12].

Pain due to muscle tension is a widely recognized complaint. Headaches, pain in the shoulders and neck pain have been labeled as myofibrositic disease and pathological changes have been found. Studies have shown that the resting tension in skeletal muscles is closely related to their use[14]. Lack of use may be the cause of this condition and exercise is frequently a very effective prescription[1].

Eighty per cent of back pain is unassociated with radiological findings[5]. The usual cause of back pain is inactivity and its many results. Treatment is gradually increased exercise[1].

Coronary artery disease is one of the greatest killers of modern times[14]. Many studies have shown that this executioner is much less common and less severe in active men[6,7,8]. Even after a coronary occlusion has occurred in animals, exercise tends to prevent another occlusion by increasing collateral flow and increased capillarization[15,16,17].

It is a well known fact that inactivity leads to osteoporosis and potential fractures.

Many studies point out that inactivity helps to produce dysmenorrhea, and that certain forms of exercise can be used successfully to treat this problem. A list of these can be found in Golub and Christaldi's article[10].

It may be that the shoulder-hand syndrome and Sudeck's post-traumatic osteodystrophy are in part due to lack of movement, for exercise is prominent in the treatment of both.

These are just a few of the problems that inactivity can help to produce and physical fitness can ameliorate or even prevent. Therapeutically, exercise is as important as many drugs.

IV. *Physiological Effects of Exercise*

Exercise can cause major changes in most of the clinical and laboratory parameters of physiological function. These changes may be qualitatively and quantitatively unique to exercise, or they may resemble changes which appear in diseases.

Exercise produces many familiar subjective and objective changes in feeling and appearance of an individual. It is not well-known that in severe exercise body temperature regularly achieves 102°F. and that temperatures up to 105°F. have been recorded[11,3].

Perhaps the changes in the cardiorespiratory system, which is subjected to the most stress, are the most interesting. Heart rate increases much more for upper limb work than the same amount of lower limb work[18]. Cardiac output may reach 35-40 litres per minute[11,19]. To achieve this, both cardiac rate and stroke volume increase. Factors that may raise cardiac rate to 180-210 beats/minute are cortical action, receptors in active muscles, other neuro-hormonal reflexes, and increased venous return[20]. These rates are reached only in severe exercise where rate keeps increasing to exhaustion. In light and moderate work an early decrease or plateauing occurs[21]. Stroke volume increases to 2-3 times normal resting volume[3,20,22]. This is achieved most efficiently by a decrease in end-systolic volume and maintenance or decrease of end-diastolic volume[19,23-26,28]. As a result of decreased peripheral resistance and increased systolic ejection both systolic and pulse pressures rise up to 280 and 180 mm. Hg. respectively[29], while diastolic pressure remains approximately the same. Exercising muscle receives some 80-90% of this increased cardiac output[27]. Coronary, skin, and respiratory muscle perfusion also increase, while flow to viscera decreases[3,22]. In severe exercise, the activity of these tissues may produce a total body oxygen demand of up to 22 litres of oxygen/minute[11]. Since maximum oxygen intake is usually about 4 litres/minute[3,11], these demands cannot be met from intake. The difference must be met from anaerobic metabolism and oxygen stores[11]. The high oxygen utilization i.e. 4 litres/minute, as opposed to normal resting utilization of 0.3 litres/minute[11], which exists in exercise is made possible by many factors, including:

(1) an increase in systematic arterio-venous oxygen difference, from 5-6 volumes per cent to 13 volumes per cent[22].

(2) an increase in muscle arterio-venous oxygen difference 16-17 volumes per cent[22].

(3) a decreased circulation time.

(4) a lower tissue oxygen concentration.

(5) a shift of the haemoglobin oxygen dissociation curve by local factors[3].

Respiratory minute volume may increase from 8 to 115 litres/minute[11]. Pulmonary capillaries open, allowing blood volume flow through the lungs to increase more than velocity of flow[30,31]. This permits the increased flow to produce only a slight decrease in percentage oxygen saturation.

Alterations in muscle hemodynamics and metabolism are noted. Many closed capillaries open[17,32,33], and will remain open despite attempts to close them such as by sympathetic stimulation[3,34]. Flow may increase from 0.16 to 12.0 litres/minute[3]. Aerobic, fat metabolism may yield to anaerobic, glucose metabolism[35,36]. This may produce up to 3 Gm. of lactic acid per second[37] which, on reaching levels of 130 to 300 mg % in the blood, is accompanied by a sense of overwhelming fatigue, and return to fat use[36]. Several investigators have had some success in delaying fatigue by alkali administration[3,11]. Muscle stops contracting because of *muscle fatigue*, not because of myoneural junction fatigue[39,40].

There are a vast number of changes in the circulating blood. Haemoconcentration[41] results from a decrease of plasma volume[43], combined with an increase in sodium, potassium, calcium, lactate, phosphate, and protein concentrations[11,44,45,46]. Splenic reaction may release blood rich with red blood corpuscles. As a result, the red blood cell count may increase as much as 200,000 to 1,000,000 greater than normal resting levels[11]. This erythraemia is only transient, for in severe exercise, especially if done by sedentary individuals, from 12 to 30% of the red blood cell mass may be destroyed, producing haemoglobinuria and subsequent increase in erythropoiesis [11,41,47,48]. Exercise may also affect the white blood cells, raising counts up to 27-35,000 and producing differentials ranging from eosinophilia to 55% lymphocytes to 90% neotrophils. Platelets may either increase or decrease[3,11,49].

Blood glucose may rise or fall[3,11]. If exercise is prolonged, a fall ultimately occurs and if not reversed, exercise cannot be continued[11]. Blood pH always decreases in severe exercise and may reach 6.48[11,51]. Because of this, alkali by mouth has been recommended by some experimenters as improving endurance.

Increase in serum vitamin A[52] and blood fibrinolytic activity[53] has been reported. Serum glutamic-oxaloacetic transaminase and other serum enzymes of diagnostic significance may change greatly in severe exercise[55,56]. They are important because they may affect crucial laboratory tests.

The kidney is deprived of an estimated 50%-80% of its blood flow[57,58,59]. Filtration fraction increases, glomerular filtration rate decreases[59]. More of the glomerular filtrate is absorbed, possibly due to increased ADH secretion. Urine pH decreases; myoglobinuria, haemoglobinuria, haematuria, albuminuria, and excretion of casts occur; and chloride excretion decreases. Urine output falls[3,46,48,59,60,61].

The ECG is affected[24]; changes occur in cartilage[1,12], and there is increased adrenal cortical and medullary secretion[62,63,64].

The changes described above are only some of the deviations from the resting normal that occur during exercise. Some of them put great strain on homeostatic mechanisms. They are of interest to the medical profession in that the understanding of these and other changes is important in the interpretation of results of many clinical and laboratory findings as well as in the prescription of the correct type and amount of exercise.

V. *The Training Process and the Trained Individual*

The nature of a training programme will depend on its objectives; for, such a program can be designed to produce increased endurance, strength, flexibility, or speed. Most studies on total body training have been done on runners, usually performing on motorized treadmills, or on a single muscle or limb trained by isometric exercise.

The endurance type of training produces marked changes in the cardio-respiratory system. At rest, endurance-trained individuals show a bradycardia, an increase in heart size, bigger R waves in left precordial leads in the ECG, larger T waves[26], lower blood pressure[1], increased resting stroke volume[1,3,20] and a better-developed coronary capillary network[17]. They may have better coronary collaterals[65], decreased cardiac output, and a more rapid circulation time[66]. However, the differences between the trained and untrained are even greater in endurance performance.

Trained persons consume less oxygen for the same amount of work[1,22,67,73] and can attain a higher cardiac output[24]. Their maximum pulse rates are lower, and their cardiac rates are lower for the same exertion.

They can do more work before reaching maximum heart rate, and their stroke volume increases more than the untrained[1,20,22,21,67,68]. On resting, their return to the pre-exercise state is mueh more rapid[21,22]. During the period of exercise the trained heart uses less oxygen than the untrained, and their T-waves are not depressed in heavy exercise as are the T-waves of the untrained heart in the same circumstances[1]. Because heart rate is lower for the same exertion, diastole is longer and coronary perfusion is better[1]. In exertion, arteriovenous oxygen difference increases less[24].

The trained have more efficient respiratory function and can attain a higher oxygen consumption. Their blood lactate levels do not inerease as much as the untrained for the same work[1,38], and they can tolerate higher lactate levels[22].

There is no evidence that heart damage can result from stressing a healthy heart[69]. Some studies show an 8 year increase in life expeetancy for the trained[24], but the consensus of opinion is that although there seems to be some improvement in coronary death rate in the physically fit, no 2 groups have yet been studied who are alike, except for their physical activity; therefore no sure conclusions can be drawn. Kraus and Raab[1] quote from 21 studies showing that coronary mortality is less in the active. The death rates in these studies, given as a ratio of active to inactive ranged from 1/1.1 all the way up to 1/5.7. Other writers also indicate that there should be an improvement in this type of death among the fit[1,6-8,70,71].

Other systems are less affected. Muscle may show a 40% increase in capillaries; myoglobin may increase its concentration two and one half times[65]. The muscle shows hypertrophy, increased number of myofilaments, decreased percentage of sarcoplasm, increased contractile strength, increased numbers of nuclei, increased protein content, lower fat content, and increased phosphocreatine and glycogen eontent[11,72,74]. The muscle itself produces less lactic acid in exercise and is more tolerant of high levels of lactic acid. Tests of renal function during exercise show decreased excretion of protein, catecholamines and other excretory products[46,60,75]. In the trained, the increase in serum protein concentration in exercise is less. Haemoglobin concentration is greater, as are blood volume, total percentage of body water, and the volume of red bone marrow[11,76]. Recovery from exercise-included haemolysis is more rapid[11]. The adrenal cortex is hypotrophic in exercised animals[3].

The factors affecting training have not been well elucidated except in the case of training muscle strength. Factors affecting other parameters of fitness are under investigation in many laboratories.

The following information has been established about the factors affecting growth in muscle strength.

Maximum growth of muscle strength is produced by a single isometric contraction lasting 1.5 seconds. To achieve optimum growth this contraction should be 40 to 50% of the greatest contraction that the muscle is capable of, and needs to be done only once each day. Isometric contraction produces greater strength than isotonic contraction. Training to exhaustion does not increase growth in strength, though it may increase the rate of capillarization. Increase in strength is maximum in summer and autumn where ultraviolet radiation is present, though vitamin D will not produce this affect. Testosterone will greatly increase rate of growth of strength. Weekly training will produce slower growth of strength but will provide better strength retention when the training period has ended. Training once every two weeks will maintain strength, but training at less frequent intervals will serve to retard rate of loss of strength. Isometric training of one limb will not produce increase in strength in the contralateral limb, though dynamic exercise will[74,77,78].

Knowledge of the factors affecting increase in endurance are less well researched. It has been shown that if heart rate attained in a standard test is used as a measure of condition, no training occurs during exercise unless a heart rate of more than 135 beats/minute is attained during the test, but that slower resting pulse, more rapid post-exercise pulse recovery, a decrease in maximum pulse rate, and improved exercise tolerance may occur[24]. It has also been shown that after a few weeks of persistent training a constant level is reached in tests. If the duration of the training exercise is increased, no improvement occurs; but if intensity of exercise is increased, improvement in the tests does occur[22].

Information such as the above is invaluable for physicians, coaches, physical educators, physical rehabilitators, i.e. all those persons concerned with increasing strength, and for all persons interested in avoiding physical weakness. Such precise information is not available for any other type of training. However, factors affecting training and the results of training as related to other parameters are slowly being discovered by laboratories such as that in the Department of Physiological Hygiene here at the University of

Toronto. As new information accumulates it becomes more evident that there are few undesirable effects of training on health.

VI. *The Future of Physical Fitness*

In the past year, the Government of Canada has allocated millions of dollars for the promotion of physical fitness in Canadians. The U.S.A. has set up The President's Advisory Council on Fitness. Many foreign countries including Switzerland, Austria, West Germany, and the U.S.S.R. maintain centres numbering into the thousands where programmes of activity are carried on to prevent further deterioration of the over-worked, under-exercised individuals produced by modern society. These are financed by industry, insurance organizations and governments as a social and economic investment[1]. The claims made for these centres and for "positive health" are rejected by western physicians.

The fact that these centres exist in Europe may mean that in the future the need for physical exercise as a preventitive measure will be recognized here. The grants made by the two North American governments seem to indicate this. As we followed the U.S.S.R into space so will we follow them into the realm of physical prevention.

Knowledge of physical exercise is of importance to the medical practitioner in that he and his patients can benefit from its judicious application both in the doctor's leisure hours and in the therapeutic prescription of exercise. When the need for physical and other types of exertion become a recognized fact, we will cease to see pain and unpleasantness in every effort required for daily living. Neither the elevator or the automobile or for that matter the "Exercycle" will ever be a thing of the past, but perhaps more people will choose to do rather than be done with by machine and entertainment.

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(References Available on Request)

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Recent Advances

IN PHARMACOGENETICS

Unusual drug responses arise either from environmental influences (for example, malnutrition, summation of drug action, concomitant disease etc.) or they have a hereditary basis.[1] The investigation of the relationship between heredity and drug response is the subject of the rapidly advancing science of pharmacogenetics.

Genes could control the response to a drug in one of two ways: (1) by determining the susceptibility of cells to the drug (for example, by determining the structure of the receptor site; or determining the presence of enzymes responsible for normal cell metabolism or stability); (2) by controlling the production of the enzymes responsible for the inactivation of the drug.

The following recent investigations clearly illustrate the genetic control of drug action in accordance with the above hypothesis.

Genetically determined susceptibility of cells to drug.

The use of primaquine as an antimalarial drug occasionally results in hemolytic anemia. In these cases it has been found that an abnormal gene on the X chromosome decreases the normal amount of glucose-6-phosphate dehydrogenase (G6PD) in red blood cells. Consequently, less TPNH is formed by the oxidation of glucose-6-phosphate and less reduced glutathione results.[2,3] Apparently reduced glutathione is necessary to maintain the structure of red blood cells and in the presence of primaquine, hemolysis results. The same side-effect occurs with sulphanilamide, acetanilide, phenacetin, probenecid and others.

Genetic Control of Enzymes which Inactivate Drugs.

The production of usual and/or atypical cholinesterase is under the control of two autosomal genes. An individual possessing atypical cholinesterase will not hydrolyze administered succinylcholine. Consequently, muscle relaxation will be greatly prolonged and apnoea will result.[4] (It must be remembered that malnutrition or liver disease could alter the concentration of usual cholinesterase and thus a similar prolonged response could result.)

Isoniazid is inactivated rapidly by some people and slowly by others. The acetylating enzyme responsible for the destruction of the drug is controlled by a single pair of autosomal genes.[2] Slow inactivation seems to predispose to neurological disorders.

Finally, another genetic abnormality may be expressed in the inactivity of glucuronyl transferase, the enzyme which catalyzes glucuronide conjugation in the liver.[4] This defect usually appears as an abnormality in bilirubin metabolism but may also affect the metabolism of morphine, chloramphenacol, acetophenetidine, or the metabolites of epinepherine, cortisone, and chlorpromazine.

Importance:

First, in the same way that the study of avitaminosis has lead to the understanding of vitamins and their biochemical and clinical importance, the investigation of abnormal drug responses has contributed to the knowledge of the mode of action of drugs and basic biochemical and physiological processes. For example, the study of primaquine toxicity has revealed the importance of G6PD in the stability of the red blood cell and suggested that the genetically determined enzymatic defect and hence the possibility of drug toxicity might be detected by examination of the blood. Similar studies could be applied to sulphonamides and others.

Secondly, the often unjustified explanation of an abnormal drug response on allergic grounds may be replaced in many cases by the concept of hereditary susceptibility;[4] for example, the hemolytic anemia often associated with primaquine toxicity was originally said to have an allergic basis.

Thirdly, several medico-legal problems are raised. Experiences with succinylcholine and isoniazid indicate that two or more distinct responses may exist for one drug; therefore, in clinical tests consideration must be given to this possibility in order to avoid the error of trying to fit all responses into one normal distribution.[2] Research with primaquine suggests that separate clinical tests may be necessary in different geographical areas. Sensitivity to this drug occurs as a genetic defect almost exclusively in countries and races exposed to malaria (eg., African negro) so that any clinical test of safety for this drug in Canada would not be valid in Africa. Furthermore, if toxicity developed to a drug in genetically predisposed person, who is legally responsible — the drug manufacturer or the patient's gene? (see page 214)

Clothing Problems in the Cold

D. Chubb 6T4

Men who live in our far northern climes must be constantly aware of the problems associated with living in a cold environment — not just for their comfort but for their very survival.

In the temperate latitudes of Southern Ontario cold is, generally, not a serious hazard. However, there are still those hearty types, who, with a zest for 'roughing it' go on hunting or camping trips, or plain hiking during our cold winter days, as well as those more "unfortunate" individuals whose occupations require long hours out of doors. It is for these latter groups that I hope this article will have some meaning.

The human body must maintain a deep core temperature close to 98.6°F by balancing heat loss and heat production with preferably as little time and voluntary activity as possible being spent in this endeavor. The human body can well tolerate a certain amount of heat debt by allowing the temperature of the peripheral tissues (skin temperature of extremities, etc.) i.e. of the shell of the body, to fall, while maintaining the core temperature which is so essential for the efficient functioning of the brain and heart. Body cooling will cause drowziness and confusion leading to coma secondary to hypothermia of the brain, and cardiac arrythmias leading to death from ventricular fibrillation — a condition defect resulting from cooling of the mediastinal portion of the core. A return to basic physics emphasizes the problem. Newton's law of cooling states: the rate of cooling of a body which is hotter than its surroundings is proportional to its surface area and to the 'excess temperature'. This is modified by air movement and body shape.

Man's emancipation from the cold environment consists of both *physiological* and *physical* methods. Physiological mechanisms consist of involuntary and reflex changes involving control of the circulation from the core to the surface of the body by vasodilatation and vasoconstriction, evaporation of moisture from the body surface, changes in energy production by shivering, and the more profound changes in the individual acclimatized to the cold. These involve both metabolic processes which allow an increased basal metabolic rate without shivering via increased liver metabolism and greater muscle tonus, as well as a recession of the volume of the core tissue being maintained at the necessary temperature thus allowing greater heat loss before one must begin to shiver — in effect the result is an increased heat storage. These individuals seem to have a greater resistance to general body cooling (hypothermia) and to local body cooling (frostbite). Physical methods consist of the use of clothing, shelter and air-conditioning.

However, as physiological adaptation incurs discomfort, man has learned to take his tropical environment with him allowing little room for acclimatization to occur. Hence, although acclimatization can and does occur, the knowledge of the problems of clothing and shelter and their intelligent utilization is far more important than that of any possible physiological changes.

The principle of clothing insulation is based on the amount of dead air entrapped and not on the textile fibres directly. The thermal insulation is then proportional to the thickness of the dead air enclosed. For entrapped air to remain 'dead', the size of the enclosed space must be small (less than ⅛ inch), or otherwise, as in larger spaces, random convection currents will be produced that decrease the insulating value. Clothing is simply a series of these small successive air spaces with the fibres merely acting as filling to immobilize effective dead air — the bulk densities of the materials always being low enough so that the conduction by the textile is negligible. Corollaries of this principle emphasize first the importance of a windproof coverall to prevent air current within the clothing, and secondly, that the necessary thickness of dead air entrapped should be maintained under service conditions of compression due to external forces or moisture loading. Wool is better able to maintain its thickness when wet than is cotton.

Simply conserving heat is not the only problem that clothing has to contend with. When one is inactive, and there are no adverse climatic conditions save cold, this may be sufficient. But when one's activity is increased, heat production will be increased (body heat production is doubled from standing to walking at three miles per hour). The body temperature will rise and sweating will occur in a physiological attempt to cause cooling, unless the clothing ensemble can adjust to allow increased heat loss during this period of increased heat production. Body movement does cause an 'internal wind' to develop which tends to decrease the insulating value of the clothing, but this is silent. Therefore, the intelligent dresser who contemplates a period of increased activity would either 'underdress' for this period and then change to heavier

clothing when inactive; or he would wear an adjustable outfit in which he could increase the body ventilation by removing headgear and gloves, undoing the coat, or even removing it so that he would not overheat. In view of this, it is apparent that several thinner layers of clothing are preferable to one or two heavy garments, as well as there being not too great a change with the environment when ventilation is required. Mothers are often most unreasonable in overdressing their small children, who, unable to adjust their clothing in a period of activity, will sweat, only later to become quite chilled when they are inactive. It should be stressed that when dressing for cold conditions, overheating is often just as much a problem as is keeping warm.

Clothing, by its very nature, inhibits the escape of water vapor. This phenomenon enhances the problem of sweating when the sweat production exceeds its evaporation and vapor transfer through the material. The resultant accumulation of water in the clothing evaporates when the individual is inactive and when heat production is not sufficient to compensate for these evaporative losses. One should also realize that even insensible perspiration may accumulate if humidity within the clothing is so great from poor transfer that evaporation is restricted. Furthermore, emotional sweating of the soles, palms and axillae is always a difficulty. Hence, clothing should be as permeable as possible to water vapor. Although, generally, our standard textiles are sufficiently permeable, the use of ventilation techniques mentioned above are effective when increased activity imposes a strain on moisture transfer. Certain design features such as the string vest help to minimize the adverse effects of accumulated perspiration in the clothing by keeping the moisture off of the skin. Finally, the intelligent choice of clothing with the avoidance of overdressing with respect to varying levels of activity, with possible minor sacrifices in comfort, should allow the clothing to function near its peak performance.

In a cold environment, the relative humidity rises as we pass out from the skin and reaches a maximum at a certain distance from the skin. Though the vapor pressure has decreased as we leave the skin, the decrease is not enough to keep pace with the rapidly falling capacity of the air to hold the moisture as the temperature falls. Where the relative humidity exceeds 100%, there will be continuous condensation of moisture, from the skin, in those particular layers of the clothing. This phenomenon of wetting out, or of a 'frost-line' occurs frequently when the temperature is below freezing. Unless the frost, or moisture, can be eliminated by shaking or by drying, it will be cumulative, and the weight of clothing or a sleeping bag becomes very great in a few days.

As mentioned above, the greatest discomfort of sweating occurs during the inactive phase following exertion; the causes are two fold. Firstly, the evaporative heat losses from the clothed body can be immense during a period when heat production is not keeping pace. Furthermore, when clothing is wet, it loses a considerable part of its power to insulate, a result of actual liquid water accumulating and displacing dead air in the fabric as well as the consequent water load which compresses the fabric. The evaporative heat losses can be ameliorated by employing clothing that imbibes water and 'wicks' it to the surface quickly. As a result of shifting the moisture a distance from the skin, the heat of evaporation is drawn from the environment as well as from the body surface rather than from the body surface alone when evaporation occurs close to the skin.

Experience has shown that while porous, open-weave or knitted garments are adequately warm on cold still days, they must be covered in windy weather by windproof fabrics. The reason is, of course, that if wind penetrates the clothing, air is no longer 'dead' and its insulating value is decreased. A good solution is the use of a densely woven outer fabric plus the assured efficiency of seals at the neck, wrist and the ankles.

Moisture from the environment presents a similar situation to perspiration, but the severity of the effects may be much greater. Cold sea water or rain in sufficient quantities may have as great an effect on heat loss as immersion in cold water. Indeed, the heat loss under very cold conditions may be so great that an individual may die from hypothermia within ten minutes. Therefore, one must protect himself with a waterproof garment. If this is of the vapor barrier type (ie: oil skins, etc.), it will cause discomfort from the accumulated perspiration. Because of the vapor barrier, the accumulated perspiration does not evaporate and hence, no evaporative heat loss occurs. Overheating may then result. Nevertheless, the protection against chilling by external water takes precedence over the discomfort of accumulated water vapor. Recent research in clothing materials is producing a waterproof coating substance that allows vapor permeability at the same time. Examples are the polyurethanes.

It is generally realized that a cold day seems much warmer when the sun is shining brightly, especially when the ground is covered with reflecting white snow. As a result, an individual venturing outside will dress less heavily than he might otherwise do at the same

temperature when there is no sun. The heat received by the body in full sunshine can amount to two or three times the metabolic rate of the body. Thus, if a person remains outside after dark or when the sky becomes clouded, without the use of additional clothing, it can easily be understood that his chances of becoming chilled will be greatly enhanced.

One should appreciate that the state of cleanliness of the clothing will affect its efficiency. Fabrics charged with dirt, grease and mineral salts from prespiration will conduct heat more rapidly. Gloves are particularly prone to this problem.

There are certain clothing features particularly related to the extremities and the head that should be mentioned. When the temperature is very cold, the use of gloves of any type that separate the fingers should be avoided because of the physics of heat loss from small cylinders with a layer of insulation In these cases a layer of insulation may actually increase the heat loss because the increased surface area losing heat outweighs the smaller thermal insulation gained. Furthermore gloves are inclined to bind and constrict blood flow. Loose fitting mittens are preferred. One will remember that their removal is always an efficient way of increasing the body heat loss to prevent overheating.

Blood flow in the hand is greatly modified by warming or cooling of the body as a whole. Therefore, even though the hands may be immersed in warm water, when the body is chilled, the blood flow in the hand remains low from vasoconstriction. If the body has become chilled, heating the hands alone is ineffective and may even be detrimental — it is more important to supply heat to the body than to the extremities.

Using a glove design with fingers flexed in the normal position of rest, instead of in the conventional extended position will prevent loss of insulation at the joints by not allowing compression of the dead air space when the hands are relaxed.

If a man must use his bare fingers for work in the cold, he should avoid lengthy exposure of the bare hands and wrists that will cause stiffening and reduced circulation, since it takes a long time to recondition the hands to normal use. He should avoid touching with bare hands any object that has a high heat conductivity when the temperature is well below 32°F or a flesh burn similar to one caused by a hot stove will result. The hands should be kept dry. If the fingers must be bare, keeping the wrists, backs of hands, and palms covered by the use of fingerless gloves, will decrease appreciably the amount of heat that is lost. Constricting garments on the inside of the upper arm, axilla and wrist, places where large blood vessels come near the surface, should always be avoided.

When fingers have become painfully cold and stiff or frostbitten, revival of normal circulation can best be restored by placing them next to warm flesh under the armpits, between the thighs, or next to the abdomen. Never treat frostbite by rapid heating over a stove, rubbing with snow, or by strong abrasive rubbing.

More than any other part of the body, the feet need special attention in cold climates. They are particularly prone to frostbite and in conditions of prolonged, damp, cold (not freezing) exposure, to immersion foot. Feet must be kept dry. In a temperature above freezing snug-fitting, waterproofed boots with frequent changes of socks, when sweat accumulates, is sufficient. However, when the temperature is well below freezing (O°C), snow becomes 'dry' and moisture within the boot will cause frost to form at a freezing line somewhere within the footgear assembly. In this case we want a boot that will permit free escape of water vapor and one that is large and roomy enough to permit the use of additional socks or insoles for perspiration absorption. Again, when foot perspiration becomes excessive, ventilation of other parts of the body, which are more accessible than the feet, will reduce the foot perspiration unless it be on an emotional basis. Feet can be kept warmer by standing or walking than sitting or lying because of increased muscle metabolism and decreased capillary constriction.

One should be able to recognize freezing of the feet. As long as easy movement is apparent and the sensation of cold is acute, freezing has not yet set in. But, if cramping prevents movement of the toes and pain of great intensity disappears without undue reason, the feet should be examined, for these are symptoms of freezing.

Preventing excessive heat loss from the head and protecting from cold injury (frostbite) are two distinct problems. The heat loss will be greatest where the skin temperature is greatest, and these regions should be most heavily insulated. On the contrary, those regions which are coldest require most protection from frost-bite.

A. C. Burton has recently shown in a study of heat losses from the head that even in a moderately cool temperature, the unprotected head constitutes a very serious 'heat-leak' of the body. At temperatures as high as 25°F, a man may lose 50% of his resting heat production through this route alone increasing

linearly as the temperature becomes lower so that 75% is lost at a temperature of 0°F. These heat losses occur without ones awareness at the time as the head is ill-equipped with sensory endings. The basis for this 'extravagant' loss is due to the head's lack of physiological responses to cold — the skin of the head seeming to be free of vasomotor control of the blood flow by autonomic nerves that is so marked in the extremities and elsewhere. As a result of this 'heat-leak' of the head, a man adequately clothed on his body but with his head unprotected, will accumulate a heat-debt, leading to eventual discomfort and loss of efficiency and reducing his total tolerance time. The major part of the heat loss is from the scalp, the area of normal hair distribution and an area that is easily protected by the use of a hat.

This great source of heat loss can also be put to good advantage by the removal of headgear when increased activity and heat production cause sweating.

The areas most likely to suffer frostbite are, in order of suseeptibility, the tips of the ears, the nose, the chin, the cheek prominences and forehead. The ears are thin and having a poor blood circulation, may freeze quickly and painfully.

In general, clothing can manage 'dry-cold' conditions most comfortably. In cold climates where wind is a factor, outer layers with a high degree of wind resistance offer sufficient protection. It is in 'wet-cold' conditions that our present clothing techniques often fail to provide adequate comfort, a result of the vapor barrier principle. But with the future development of vapor permeable, waterproof coatings, this difficulty will be minimized. Clothing that is lightweight and pliable gives the best effieiency. The importance of covering the head when inactive in cold weather has generally not been appreciated. Finally, clothing should be thoughtfully adjusted to bodily needs and not worn merely as a matter of convention without consideration of the climatic environment and the bodily activities to which the individual will be exposed.

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(Cont. from page 218)

Diabetie passengers should carry sugar or candy to avoid insulin reaction.

Passengers requiring special care are advised to travel with someone capable of attending to their needs or operating special equipment.

The airline companies have specific policies regarding transport of medical cases. Medical personnel are on staff of these companies, and they are always eager to provide information or advice about doubtful cases.

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Pheochromocytoma of the Urinary Bladder, D. W. *Blair, A. W. Branwood*

About ten percent of pheochromocytomas are located in extra-adrenal sites, The tumor, regardless of location, presents with attaeks of hypertension, sweating, tachycarcia, vomiting, headaches and pallor. Associated with urination or distension of the bladder, these symptoms suggest that the bladder is the site of the lesion, as occurred in the case presented here. Although usually non-secretory, these tumors should be removed because of the possibility that they may become secretory with the resultant difficulties in management.

Medical Horizons:

OBSTETRICS, ITALIAN STYLE

Bernard Rasminsky, 6T5

Florence, Italy, represents to me one half of the eternal conflict between religion and reason, art and science, the old and the new. In contrast to the sterile, futuristic look of Stockholm, or the crisp freshness of Copenhagen, Florence is medieval. I, unlike many others, was unable to fall in love with this city of the past, which I feel is desperately trying to retain its semblance of the Italian Renaissance. In the midst of a centre filled with the artistic riches of the Italian masters, present day Florentines barter with "rich" Americans in the famous straw market.

My view of Florence was perhaps unique. Many tourists see it in a day or two, whereas I had the opportunity of working in a hospital there for a month with a classmate from Toronto. We worked at a new obstetrical and gynecological unit, which was a part of the University hospital. The building was a self-contained entity recently constructed and serving only its own specialty. We were given a spacious room in the doctors' quarters, and were only steps from the labour rooms. The hospital was bright, shiny and equipped with many ultra modern conveniences. The operating rooms were equipped with television cameras and up-to-date anaesthetic machines. Each doctor on call carried a transistorized receiver in his pocket, which buzzed to notify him when he was needed. We spent time in the endocrinology department, where hormonal assays and pregnancy tests were done. In "out-patients" we observed and assisted in the preparation of papanicolaou smears.

In prefacing my comments concerning Italian medicine, it must be pointed out that my experience with it was indeed limited, and my basis of comparison is far from comprehensive. Nevertheless, certain things were blatantly obvious. In this hospital, operating surgeons wear masks under their noses. This they can probably justify, but I am unable to reconcile the occasion when I stood beside a surgeon who sneezed into a gaping vaginal incision. I personally saw a young resident watching a dilatation and currettage from a distance of ten feet, with a lit cigarette behind his back, and on another occassion I saw a burned out match on the operating room floor.

The two gynecologycal operating rooms are separated by an open passageway and each room has two operating tables, twenty feet apart. These are used simultaneously. A patient, quite conscious, will be wheeled in past the first table (where an operation is in progress) and put on the second. At the end of an abdominal hysterectomy, the unconscious patient is lifted in the arms of one, quite small orderly and "dropped" on a stretcher. The method of cleaning the hospital floors is also a revelation. It was with a good deal of dismay, my first morning in the hospital, that I looked down a hallway absolutely covered with moist sawdust, and saw two or three nurses with brooms proceeding to sweep. It was at that point that I was presented with a conflict, whether to cry or pick up a broom and help. It is not my purpose to make jest at Italian medical people, but it seemed almost ludicrous that with such excellent basic facilities, this sort of routine was being practiced.

Yet, to even a non-patron of the arts, Florence, the ancient city of the Medicis, must make an impression. The view from the Boboli Gardens, or from the Piazzale Michelangelo at sunset is breath-taking. The centre of the city consists of the Piazzi del Duomo, in which stands a most magnificent cathedral. It is here that Ghiberti's famous doors, the "Gates of Paradise" can be found. A short walk from the Duomo brings one to the Uffizi Gallery, which contains one of the world's most important collection of paintings. Representative of the Florentine and Tuscan schools of the Thirteenth to Seventeenth centuries, are works by such masters as Correggio, Bottecelli, DaVince, Raphael, Del Sarto and many others. Perhaps for me, the most meaningful sight in all of Florence was Michelangelo's David. As one walks down the narrow, darkened hallway of the Galleria Dell Accademia, past Michelangelo's four unfinished statues of "the prisoners", one comes to stand at the base of the most magnificent statue imaginable.

Before closing, I must mention Viareggio, a small seaside resort on the Mediterranean. For six dollars, inclusive of train fare, room, delicious food and a big litre bottle of chiante, I spent a week-end in Viareggio. It is frequented only by Germans and Frenchmen, untouched by American tourists and the soaring prices they bring — a true student's haven. (This one cannot even be found in "Europe on Five Dollars a Day.")

In looking back on my short sojourn in Italy, my main regret was my total inability to speak the language, and with this, my inevitable failure to truly understand and appreciate the Italian people.

EVERYTHING ON HER MIND BUT HER DANDRUFF *(that's on the downtown list)*

Strange how many patients catalog their ills (real and imagined) from day to day, yet never mention their dandruff to their doctor. They'll tell everybody else about it, *but they just don't think of a scaly scalp as a medical problem*. And so they scratch and suffer and suffer and scratch, and make one costly experiment after another. That's why a word from you (if you can get one in)—and a prescription for Selsun—will probably be appreciated.

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Ionizing Radiation

P. R. Mahoney, 6T4
R. W. Shaw, 6T4

A. INTRODUCTION

On December 30th, 1958 at Los Alamos, an electric stirring device was turned on in a nuclear reactor; there was a sudden blue flash and a "muffled" report. The workman standing on a ladder looking into the tank was thrown to the floor. He immediately ran outside the building and cried that he was burning up. His skin quickly reddened. Within a few minutes he began to vomit and to discharge a profuse watery diarrhea. He was taken to hospital in shock and died shortly after admittance.

This tragic accident illustrates the extreme end of the spectrum of the deleterious effects of environmental ionizing radiation occurring as a unique exposure in an uniquely exposed occupation. This clinical picture would be commonplace on the uncomprehensible, unforgiveable, infamous day of total nuclear war. At present in the general population, the deleterious effects of radiation are operating in a less dramatic way: a slight elevation in the incidence of leukaemia, of abortions, of congenital deformities; a slight decrease in the life expectancy; a slight alteration in the sex ratio. These effects are not unequivocally demonstrable, but statistically go hand in hand with the benefits to mankind of improved medical diagnosis and therapy, and of almost inexhaustible sources of energy provided by nuclear power reactors.

Radiation is not a new factor in man's environment. Indeed, man has been irradiated since the beginning of time from the surrounding rocks and air, from the materials with which he builds his houses, from outer space and even, from the constituents of his own body. Indeed, man might even have been produced by radiation induced mutation of some prehistoric primate.

In 1895, Roentgen announced his discovery of X-radiation and in 1896, Becquerel discovered radioactivity. Shortly afterwards, the Curies isolated radium. Since their discovery, X-rays and radium have been used in the diagnosis and treatment of disease. Within a year of Roentgen's discovery, a description of radiation burns of the skin caused by X-rays was published and by 1902, there was good evidence that these rays could cause cancer.

In 1942, the first nuclear reactor came into operation under the stadium at the University of Chicago and the atomic age dawned, a new industry was created and the results of 175 nuclear explosions have been broadcast over the surface of the earth.

Terminology

Radiation is a form of energy, either electromagnetic or particulate, which may be classified into ionizing and non-ionizing forms (for example ultraviolet and infrared). In this article, we shall consider only various aspects of ionizing radiation.

Ionizing radiation consists of alpha particles, beta particles, and gamma radiation produced by the decay of the unstable nuclei of radioactive isotopes either naturally occurring or man-made, and of X-radiation produced by the bombardment of atoms by electrons in X-ray machines. Significant properties of these types of ionizing radiation may be tabulated as in Table I

Radiation	*Charge*	*Relative Mass*	*Degree of Ionization*	*Penetration Air*	*Penetration Tissue*	*Suitable Shielding*
Alpha	2+	1	dense	few cm	0. mm.	paper
Beta	1−	1/1846	moderate	few metres	1-5 mm.	plastie
Gamma or X	0	0	light	great	great	level

Alpha Particles

Because of their relatively heavy size and their charge, they penetrate very poorly and shielding required is minimal. These particles lose their energy in a small area and therefore produce heavy ionization. Alpha particle emitters are not dangerousexternally or on contact but are extremely dangerous internally. The main emitters are heavier radioisotopes such as radium and radon. The internal ingestion of these emitters has not been an uncommon historical event. One of the best known cases was of the radium dial painter who about forty years ago inhaled or accidentally swallowed luminous paint containing radium and mesothorion and developed cystic bone degeneration and as a late effect osteogenic sarcoma. The pitchblende miners of Schneeberg and Joachamistahl, Germany, worked in an atmosphere of

radon at a concentration which is now considered to be 30 times the permissible dose, and for generations were noted to have much higher incidence of lung cancer than the general population.

Beta Particles

They have greater penetrating power than alpha particles, due to their smaller mass and change and so produce only a moderate degree of ionization. Beta particle emitters are dangerous whether in contact with skin or taken internally. A common beta particle emitter strontium 90 may be imbibed by the general population in food — especially milk. This isotope is metabolized by the body and stored in bone analogous to calcium deposition.

Gamma Particles and X-radiation

They have neither mass nor charge and so have an extremely high penetration but conversely only produce mild ionization. They are dangerous both externally and internally. Cesium 137, a gamma emitter, is ingested and metabolized by body in a manner similar to potassium. Although there is no evidence that cesium is stored for prolonged periods in the body, it is distributed in all tissues including gonads. Its penetrating radiation will reach gonads from anywhere on the body.

The energy of ionizing radiation is not constant for a particular type of radiation. Alpha and beta particles have varying energy depending upon their velocity; the energy of gamma and X-radiation depends upon their wavelength. Whereas the wavelength, and therefore energy, of X-radiation may be varied (by varying the voltage of the machines), the energy of the other types of ionizing radiation varies with the source. For example, in considering beta radiation, we may talk of soft beta radiation (low energy) as emitted by phos-14 or hard beta radiation (high energy emitted by phosphorous 32. Because of this variance in energy of each type of ionizing radiation and because of the variance in penetration of each type of radiation, the amount of radioactivity i.e. the number of atoms disintegrating per second as expressed by the unit "the curie" is not biologically useful. Radiation units are, therefore, expressed in terms of the energy transfer when ionizing radiation interacts with matter.

A *rad*:—is defined as that amount of ionizing radiation that releases 100 ergs of energy in one gram of any material. To give some idea of the size of the unit, 420,000 rads would raise the temperature of water by one degree centrigrade if all the absorbed energy were converted to heat. For many years, the *roentgen* (r) was the customary unit for the amount of radiation and is defined in terms of its ionizing effect in air under standard conditions. Because of the different penetrating powers of ionizing radiation, this unit is only of use at present for X-rays and gamma rays of low or medium energy for one r of such rays to water or soft tissue administers an absorbed dose of approximately one rad. This unit has the advantage that the ionizing effect is easily determined by relatively simple physical instruments such as scintillation counters; whereas, the rad must be estimated by the use of model systems involving body phantoms i.e. inert materials with the same absorption and spatial arrangement as the human body.

Another radiation unit frequently used is the *rem* which takes into account the comparative biological effectiveness of the type of radiation as well as the amount of absorbed energy. By definition, one rad of X-rays, gamma rays or beta rays is equivalent to one rem. One rad of alpha rays, however, is equivalent to about 10 rems.

SOURCES OF RADIATION

Natural Sources

The natural radiation to which mankind is exposed is delivered mainly by specific radioactive elements which have always existed in earth and atmosphere.

Terrestial

The significant radioisotopes present in the earth all have a half-life (time for ½ the radioactive atoms to disintegrate) of 700,000 years of more, and presumably were formed during the cataclysmic events resulting in formation of the earth. The more important ones are uranium 238, thorium 232 and potassium 40. The concentration of these elements in the earth's crust varies with the type of rock, being of much higher concentration in granite than in shale or limestone. This difference is significant to cause a two-fold increase in background radiation from granite. These elements are present in brick, stone and mortar, and thus a brick or stone house has higher level of background radiation than a frame. Paradoxically, if the background radiation is largely due to beta rays, then concrete houses offer more protection than do frame houses. In certain geographic areas, these elements are sufficiently concentrated to be economically mined. In these areas, the background radiation may be 10 to 20 times the world average. These terrestial isotopes contaminate food, water and air and may be ingested by man, e.g. radon 222 and potassium 40.

Cosmic Radiation

Cosmic radiation comes from the sun and other stars in our galaxy and is composed largely of protons and alpha particles as well as a smaller atomic nuclei. These primary particles lose their energy as they pass through the earth's atmosphere producing a secondary

radiation consisting of beta and gamma rays as well as neutrons and subatomic particles termed mesons. Only the beta rays and mesons reach the earth at sea level. The intensity of cosmic radiation increases geometrically with altitude as a consequence of decreased atmospheric absorption there being approximately a threefold increase in dosage in going from sea level to 5000 ft.; it also varies with latitude as a consequence of the earth's magnetic field (reduced at the equator).

Cosmic radiation, chiefly through its content of neutrons, creates long-lived radioactive isotopes in the atmosphere. The most important of these is carbon which is formed from the neutron bombardment of atmospheric nitrogen. Tritium (hydrogen 3) is also formed by cosmic radiation but in significant amounts. Both of these isotopes readily enter the biosphere and equilibrate throughout body tissue.

Man-made Sources

Radiology

At the present time an increasingly significant man-made source of radiation is the medical and dental use of X-rays, along with the use of isotopes for diagnosis and therapy. Diagnostic radiology makes by far the most significant contribution to radiation exposure of the general population. The amount is extremely variable and depends in part on the affluence of the society (reflected in total number of procedures carried out) in the skill of the radiologist and in the precautions observed. Since diagnostic radiology involves regional rather than whole body radiation, it is obvious that the closer the procedure is to the gonads the greater the genetic significance, i.e. Chest X-ray (10-30 m.rem/sec of exposure) delivers much smaller dosage to gonads than bladder X-ray (100-1500 m.rem/sec of exposure). Fluoroscopy results in most significant exposure chiefly because of the duration of radiation, e.g., fluoroscopic examination of the colon using a barium enema will expose testes to a dosage of up to 6 rem/mm.

Fallout

Radioactive Fallout from the testing of atomic weapons has recently received considerable publicity as a source of ionizing radiation. The contribution to the environment by a nuclear weapon explosion depends upon the type of weapon (ratio of fission to fusion), the yield of the weapon, the site of explosion (underground, underwater, at or near the surface or in the atmosphere) and its geographic location. The atomic weapons in the megaton (equivalent to 1 million tons of TNT) range are fission-fusion-fission processes. The fusion process produces tritium as its radioactive debris; i.e. whereas the fission process produces over 200 radionuclides in its debris, most of which are short-lived. The significant longer-lived radionuclides are strontium 90 and cesium 137. The concentration of radioactive fallout increases in direct proportion to the yield of the nuclear explosion. The site of the nuclear explosion affects the quality, quantity and duration of fallout. Underground explosions, although severely contaminating to the local and underground streams, produce no fallout. Underwater explosions produce chiefly tritium and this is diluted to insignificant amounts by the hydrogen content of the earth's water. Explosions at or near the surface produce a great deal of local fallout because heavy surface particles are sucked up in the fireball of the explosion and made radioactive by the weapon's primary radiation. Under the influence of gravity, these heavy radioactive particles are deposited at the site and downwind for many miles. (The fallout from a megaton explosion would produce an accumulated lethal dosage within 18 hrs. at a distance of 100 miles). Fallout injected into the troposphere (the atmosphere up to 10 to 15 kilometers depending on latitude) will be circulated by winds in the latitude of the explosion and will be brought down by rainfall for a period of several weeks. Stratospheric fallout produced by explosions in the atmosphere and high yield ground level explosions will last for several years and deposit mainly in the hemisphere in which the explosion occurred. Because of its widespread and prolonged nature, this type of fallout will have the greatest effect on the genetic constitution of general population.

The significant constituents of stratospheric fallout are strontium 90 and cesium 137. These two isotopes are relatively long-lived (half lives of 28.0 and 26.6 years respectively) and are metabolized by biological systems and eventually by man. Strontium 90 contaminates milk and to a lesser extent, meat and vegetables. It is concentrated in the growing end of long bones especially in young children. Cesium 137 is widely distributed throughout the body and due to emission of pentrating gamma radiation, will cause more significant exposure to gonads. Its biological half life is of the order of 6 months as compared to 30 years for strontium 90.

Nuclear Warfare

Obviously, the greatest radiation exposure would occur in total nuclear warfare. It is estimated that nuclear warfare limited to military targets alone would kill 35 million people in the United States (90 per cent through fallout). This is aside from the genetic damage that would be produced by years of exposure to heavy stratospheric fallout; or the economic damage produced by contamination of thousands of acres of agricultural soil, or the erosion secondary to the flooding as the result of the demolition of our forests by firestorms; or the ravaging of the population, animals, and plants by plagues of newly mutated viruses and bacteria

for which there would be no natural immunity. In short, nuclear warfare is unthinkable.

Occupational Exposure

A relatively small but increasing fraction of the population is concerned here. Nuclear energy is being exploited to run power generators, to run ships and at present, there is even speculation about digging a new ocean-level Panama Canal using nuclear explosions. Examples of potential industrial exposure to ionizing radiation include: X-ray examinations of welds and treatment of plastics (so that they may be dyed); uranium mining; the handling of radioactive wastes; radioisotopes used in static eliminators, in thickness and depth gauges, in pipe leaks detection, and in luminous dials. Occupational exposure also occurs in medical radiology and in many fields of biological and industrial research. A small amount of radiation is emitted by television sets and so a television repair man may also be considered to be occupationally exposed. The chief dangers to the population lie in the indiscriminate use of radiation and radioisotopes and in the disposal of radioactive wastes which are often dumped into the local waters as at Chalk River where they are concentrated by the fish. To date, there have been six major nuclear accidents but in only two has there been a substantial release of radionuclides — one at Chalk River and one in Windscale, England. This latter accident was especially significant in that it released large amounts of the short-lived radioisotope iodine 131 which was quickly concentrated in the milk of local dairy herds. The population was protected by controlling the consumption of milk and vegetables for an area of 500 square kilometres around the reactor site.

Average approximate annual doses to the population may be tabulated as follows (in rems):

Background	*Gonadal Dose*	*Marrow Dose*
Cosmic rays (at sea level)	0.025	0.022
Internal Radio-isotopes	0.050	0.050
Air, rocks, bricks in buildings	0.050	0.050
Total	0.125	0.122
Nuclear Testing		
External	0.025	0.031
Internal		
Carbon 14	.022	.022
Cesium 137	.003	.004
Strontium 90		.005
Total	0.050	0.062
Medical Diagnostic Radiology		
	0.014 (National survey U.K. hospitals 1957-58)	

As already discussed, many of these results are highly variable e.g. background varying with altitude, type of bedrock etc., nuclear fallout being higher in the northern hemisphere and medical radiology depending on the standards and procedures of individual countries. In the national survey of U.K. hospitals, it was found that if procedures were elevated to the standards of the 25 per cent of hospitals with lowest gonadal dosage the annual exposure rate could be reduced to .006 rem.

B. EFFECTS OF IONIZING RADIATION

The effects of radiation depend upon the dose received, the rate of dosage, the extent and part of the body irradiated, the penetrance of the radiation, the age of the individual irradiated, and non-specific variable individual suspectibility. For purposes of discussion, it is convenient to consider the acute effects of radiation and the chronic somatic and genetic effects.

Information on these effects has been obtained from the following retrospective studies of: (1) radiologists (pioneer) and their technicians (2) atomic physicists (3) patients exposed to therapeutic and diagnstic radiation (4) Japanese atomic bomb survivors (5) victims of unexpected fall-out after atomic weapon tests (6) victims of atomic reactor accidents and (7) experiments on lower biological forms, especially mice and fruit flies. These experiments are of value in ascertaining the genetic effects of radiation because rapid generation times and controlled matings are required. The level of radiation dosage may be carefully controlled and information may be garnered on whether or not there is a threshold of dosage below which there is no lasting deleterious effect from radiation.

Acute Exposure

Acute total body or regional exposure may cause various syndromes or modes of death depending on the dose level and time after exposure. Very high doses (tens of thousands of rads) cause marked symptoms of brain dysfunction and "CNS" death in a few hours. There is swift progression from listlessness, drowsiness and languor to severe apathy and prostration; with doses greater than 5,000 rad, there is ataxia, convulsions, and inevitable death. This type of death may also be produced by radiating the head only.

Reduction in the dose (500-2000 rad) will increase survival time up to 3 or 4 days, when the "gastrointestinal" type of death is seen. Prodromal nausea and vomiting is soon followed by abrupt onset of anorexia with high fever and persistent loose water diarrhoea which rapidly becomes bloody. Severe para-

lytic ileus, dehydration and hemoconcentration develop, and the patient dies of circulatory collapse. Fluid replacement at the third or fourth day after exposure would prolong life, but doses that cause this intestinal damage also damage the marrow irreversibly. This syndrome may be produced by regional application of similar dose levels to the abdomen.

After lower doses of radiation (below 500 rad), a "hemopoietic" death may occur. This syndrome is typically biphasic. Initially there is anorexia, apathy, nausea and vomiting and some diarrhoea which is maximal 6 to 12 hours after exposure and may subside in 24 to 36 hours. The patient enjoys apparently normal health until about days 19 to 20 when he has chills, malaise, fever, headache, fatigue, anorexia, dyspnea on exertion and partial or complete epilation. The patient then develops a sore throat accompanied by sweliing of gingiva and tonsils, petechiae in the skin and a tendency to bruise easily, followed by haemorrhage from the gums and ulcerations on the gingiva and tonsils. Similar ulceration in the intestine causes a renewal of diarrhoea. The patient has a high fever and complete anorexia. Weeks 5 and 6 after exposure are critical, with anemia and infection due to the decrease in circulating granulocytes and lymphocytes, impairment of antibody production, impairment of both granulocytic and reticuloendothelial, functions, with lessened resistance to diffusion in subcutaneous tissues and haemorrhagic ulceration creating a portal of entry for bacteria. If nausea and vomiting are absent, it may be assumed that exposure dose is relatively low. A lymphocyte count provides a valuable early prognostic criterion for radiation injury; if after 48 hours the lymphocyte count is 1200 or more, it is unlikely that the individual has received a fatal exposure; counts below 300 indicate a lethal exposure.

The LD_{50} of total body exposure to ionizing radiation in the absence of complicating thermal injury, trauma or therapy is probably about 360 rad. The lethal range is probably 200 to 700 rad. Higher doses may be sublethal if fractionated over several days, but its difficult to say how much more radiation may be tolerated without being fatal as this is subject to individual variation.

Acute partial body irradiation at high dosages would probably be uncommon as an environmental exposure except perhaps from therapeutic radiology. If the dosage is sufficiently high, any body organ would suffer severe damage. More sensitive organs are the lens of the eye and the male gonads. In the mouse, doses as low as 15 rem produce minimal lens opacities, and in man a single dose of 200 rad produces radiation cataract. Doses as low as 30 rad may be injurious to the human testis and temporary sterility of a year's duration follows an exposure of 250 rad. A single dose of 400 to 600 rad may cause permanent sterility. Radiation nephritis has been described after local irradiation of the kidney region with doses greater than 1000 rad. Gastric ulcers may be produced a few weeks after local exposure of the stomach to 1000 to 1200 rad. Skin contamination with beta emittors sufficient to provide a dosage of 4000 rad will produce severe burns.

The harmful effects of ionizing radiation on the human embryo were noted as early as 1901. Since then many radiation-induced malformations have been recorded. These most frequently involve the central nervous system (e.g. microcephaly, mongolism, hydrocephalus); the eye (e.g. microphthalmia, cataract, chorioretinitis) and the skeletal system. Typical causative dosage ranged from 30 to 250 rad. Since frequency of malformations is highest in the period of major organogenesis, and since part of this period takes place before pregnancy is suspected a suggestion has been made that whenever possible pelvic irradiation of women of child-bearing age should be restricted to the two weeks following the menses. Some investigators also report late effects of foetal irradiation such as leukemia, cancer, stunted growth and mental retardation.

CHRONIC EXPOSURE

Somatic Effects

Late effects of acute and chronic exposure to ionizing radiation include shortening of the lifespan although this has never been adaquately demonstrated in man. Early studies on the life expectancy of radiologists have shown it to be less than for the general population. However, in recent years their expectancy has been approaching that of the general population as adequate radiation protection has been practised. In mice, it has been established that radiation will shorten life by between 4 and 9 days per rad of exposure; there is apparently no threshold for this effect. The mechanism of life shortening is not known, but it appears that the exposed animals develop the diseases peculiar to their species at an earlier age or, undergo physiological deterioration due to senescence at an earlier age. Any new diseases induced by radiation that shorten the lifespan may well be only "new" because the normal lifespan falls short of the long latency of these diseases.

Enough radiation to almost any part of the body increases the incidence of malignant neoplasia. Much evidence indicates that there is a threshold level for tumour induction. These tumours are characterised by a fairly long latent period and a variable response to dosage: some such as thymic lymphoma increase in incidence with increasing dosage, others such as hepatoma and pituitary adenoma have their highest inci-

dence at intermediate dose levels, while common neoplasms usually decrease in frequency with increasing dosage. The effects of radiation on the induction of some tumours may be mediated indirectly by physiological mechanisms and not by direct action on the precursor cells. The type of tumour induced may also vary with the age of the organism. In mice, osteogenic sarcoma and tumours of the gastrointestinal tract are more prevalent in young animals while tumours of the mammary gland and leukemia are more prevalent in older animals.

In man, the dose-effect relationship for the induction of neoplasia is not known. The reasons for this are the small numbers exposed and the rarity of the tumours typically induced by radiation in the general population. If in considering a hypothetical case in which the incidence of a particular neoplasm increased by one/million population/rad, then to assess the effect of 5 rads of exposure it would be required to study 600,000 exposed along with 600,000 suitable controls for 10 years just to give results that were statistically significant.

Studies on Japanese atomic bomb survivors suggest that the increase over the natural incidence of leukemia is 100 cases/million population/100 rad for each year of risk. Atomic bomb survivors have been shown to have a slight increase in the incidence of neoplasia involving the stomach, lungs, cervix, and ovary. As mentioned before, luminous dial painters had an increased incidence of osteogenic sarcoma and uranium miners had higher incidence of lung carcinoma.

GENETIC EFFECTS

Ionizing radiation has been proven to be mutagenic in every plant and animal species in which it has been adequately investigated. It is the rare mutation that in the long run results in a measureable improvement in the organism that receives it (for example, with a complex protein molecule such as haemoglobin there is only one correct way of producing it but thousands of ways of altering the type and sequence of the constituent amino acids to produce a physiologically defective molecule). The mutagenic effects of radiation are especially serious because there is no dosage threshold and these effects are not reversible and so accumulate until counterbalanced by natural selection i.e. removed from the population by "genetic death" (embryonic death, perinatal death, death prior to reproduction, decreased fertility, and infertility). With our humanitarian social structure, the full powers of natural selection are not operative thus an increase in the mutation rate means a tremendous and incalculable increase in the social burden.

The increase over the natural mutation rate produced by man-made radiation is uncertain. This is partly because lethal (dominant) mutations would largely result in embryonic death whereas recessive mutations, which in the main would accumulate in the population, will take many generations to express themselves in statistically detectable homozygous recessives. Obviously if the general exposure of the population went unchecked, irreparable damage could be rendered to entire societies before an accurate dose-effect relationship could be established.

What is believed to be a fairly accurate estimation of the dose-mutagenic effect relationship of ionizing radiation comes from studies on special strains of mice which were homozygous in 7 recessive traits. It was found for high dose X-radiation given as a single dose the mutation rate was 2×10^{-7}/gene/rem. Since the natural mutation rate for these mice was known to be 4×1^{-5}/gene/generation this meant that the so-called *"doubling dose"* (the dose of radiation which results in a doubling of the natural mutation rate) was 200 rem. Since other investigations suggested that the mutation rate in mice was only about one-quarter as sensitive to radiation as in man (partly due to the shorter life-span in mice) and since the mean age of childbearing for the population is 30 the doubling dose in man is therefore estimated to be from 30 to 80 rem accumulated from conception to age 30.

A doubling dose of radiation to a population would have a severe impact for it is estimated that a doubling dose to a single generation would increase the number of infants who have or will develop severe hereditary defects from the present 4 per cent to a level of 5 to 8 per cent for dozens of generations.

The estimated doubling dose has been used as a guide for the establishment of maximum permissible levels to the population, including those occupationally exposed. When one speaks of permissible levels one runs the risk of implying a "safe" level of radiation. In truth, the only safe level of exposure is none at all. One also implies a degree of knowledge not yet at hand and it must be borne in mind that man has always tended to underestimate the hazards of radiation and even the amount of exposure to radiation. Permissible exposure levels have been revised downward repeatedly since the first suggested exposure limit in 1925 of 0.1 to 1 rem maximum *daily* dose.

The International Commission on Radiological Protection in 1958 stated: "Estimates by different international and national scientific bodies indicate that a per capita gonad dose of 6 to 10 rems accumulated from conception to age 30 would impose a consider-

able burden on society due to genetic damage but that this additional burden may be regarded as justifiable and tolerable in view of the benefits that may be expected to accrue from the expansion of the practical applications of atomic energy." Medical exposure in some countries is as high as 4.5 rem per person from conception to age 30. This level is quite variable, as is the background radiation. Therefore this commission established the maximum permissible dose accumulated from conception to age 30; the commission also recommended that medical exposure be kept as low as possible.

The commission also set maximum permissible limits for those occupationally exposed by working in "controlled area" which they defined as "an area where those occupationally exposed could receive doses in excess of 1.5 rem per year". They recommended that the maximum permissible total dose accumulated in the gonads, the blood-forming organs and the lenses of the eye at any age over 18 years should be governed by the relation $D = 5(N-18)$ where D is the tissue dose in rems and N is age in years, with a maximum accumulated dose by age 30 of 60 rems. For those 18 years and under the maximum permissible exposure is limited to 5 rem per year. This implies a maximum weekly permissible dose of 0.1 rem for those continually exposed. The commission also suggested maximum permissible limits of 1.5 rem annually for those exposed in "special groups" which they defined as (1) adults working in the vicinity of controlled areas (2) those who enter controlled areas briefly in the course of their duties and (3) members of the general population who live in the neighbourhood of controlled areas. The commission felt that the maximum dose should be lower for these groups because they would represent a large fraction of the population and would include children and pregnant women.

It is to be noted that the maximum permissible exposure to age 30 of those occupationally exposed is 60 rem and of those in the "special groups" as high as 27 rem and yet the maximum permissible exposure to the population is 5 rem. This means that a small portion of the population will receive a larger share of the maximum permissible dose and so to maintain the average the majority of the population must receive less. This also means that there is a limit on the fraction of the population which can be exposed occupationally or be part of the "special groups". The commission therefore pointed out that the maximum permissible dose should be apportioned and they gave the following illustrative opportionment:

Occupational exposure	1.0 rem
Exposure of special groups	0.5 rem
Exposure of population at large	2.0 rems
Reserve	1.5 rems

This would mean that a maximum of 1.7 per cent of the population could accumulate the maximum permissible occupational exposure and about 3 per cent could be exposed maximally in the "special groups." At the present time the number of persons occupationally exposed in technologically developed countries is about 0.1 to 0.2 per cent of the population, and most of these receive doses which are considerably less than the maximum permissible doses. With rapid expansion of the peaceful uses of atomic energy there could conceivably be a danger of running out of workers. However, since the size of these groups varies inversely with the average dose within these groups an adequate working population could be ensured by appropriate safety measures and increased use of automation. The exposure of the population at large would be due to contamination of the atmosphere and water resources from radioactive wastes and industrial accidents. This exposure could be kept quite low by adequate safeguards and thus permit an increased share of the permissible exposure to be allotted to those occupationally exposed.

C. PREVENTION OF RADIATION DAMAGE

The essence of prevention of radiation damage is PROPHYLAXIS. This includes strict regulation and control of ionizing radiation, education of workers and the general public; and research to recognize, to assess and to discover new and better methods of prevention.

Background

Very little can be done here. Communities should not be established in zones with excessively high background radiation.

Medical

Exposure could be reduced without altering the therapeutic or diagnostic effectiveness (as illustrated by the United Kingdom radiological survey in 1957). Some possible ways would be:

(1) Restrict the diagnostic indications especially in patients below 30 and pregnant women.

(2) Limit therapy to only malignant conditions.

(3) Improved X-ray technique by use of aluminum filters to block soft X-rays which do not produce an image, by use of cones and collimators to limit the area exposed, by use of gonodal shields, and by use of supersensitive films to keep exposures to a minimum.

(4) Judicious use of fluoroscopy. Reduce exposure by use of image intensifiers, by use of timing devices, by proper dark adaptation on the part of the examiner so that minimum of filament current is needed.

Industrial Exposure

(1) Careful accurate assessments of exposure, by monitoring with film badges or pocket dosimeters and complimented by periodic medical examination (including blood counts).

(2) Restricted entry to areas of high radioactivity. Monitoring of personnel working in these areas and decontamination as required.

(3) Remote control of radiation sources, protective shielding and clothing.

(4) Effective disposal of radioactive wastes. At present, some industries utilize dilution in local waters and soils. This is sufficient only if the radioisotopes are short-lived and the industry is located far enough away from population centres. The burial of radioactive wastes in the ocean depths may seem to solve the problem. However, containers soon erode and release their contents to the deep sea currents for wide distribution. More research is definitely indicated in this area.

Nuclear Testing

This is the most controversial aspect of prevention of radiation exposure. Fallout from nuclear testing, if continued at the level of recent years would result in a cumulative exposure from conception to age 30 of only about 0.1 rem. Proponents of continued nuclear testing have pointed out the significance of this low level of exposure. However, any level of radiation has a deleterious effect, and this particular source of exposure is the only man-made exposure which is involuntary and yet readily avoidable. Actually this controversy only begs the issue, for the proponents of the nuclear test ban in reality seek to lessen the possibility of nuclear war.

Conclusion

Ionizing radiation has already made significant contributions to the betterment of our way of life, and with continuing research and development stimulated by our dwindling reserves of biologically-derived sources of energy, it will play an ever increasing role. The present exposure of the population is well within the permissible limits, although continued research is required to confirm this. With increasing awareness of the hazards of ionizing radiation and increasing investigation of their methods of control, increased peacetime usage of atomic energy should only be beneficial to society. It should again be emphasized that total nuclear war is unthinkable and it would be desirable to see greater economic emphasis on research for peace at the expense of the development of missiles and atomic weapons.

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(continued from page 200)

Summary

As the interplay between heredity and drug response is clarified through further investigation, "the element of surprise in the use of drugs" may decrease and safety in their use may increase.[1]

Acknowledgement K. W. Johnston

The author wishes to thank Doctor W. Kalow for his assistance in preparing this article.

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Recent Advances

Gastric Hypothermia

In medicine there exists a feud (albeit a friendly one) between the fields of internal medicine and of surgery. Each maintains a public attitude of slight superiority, and seldom does either miss an opportunity to denigrate the other. With the advent of gastric hypothermia internal medicine has been given a chance to strut, for this technique permits the internist to keep the patient with duodenal peptic ulceration or upper gastro-intestinal hemorrhage out of the surgery ward for a more prolonged period than was formerly the case.

In 1962 Wangensteen published his first results on the use of gastric freezing in the treatment of duodenal peptic ulcers. Utilizing this technique, persons were freed of ulcer symptoms for at least a few months, and this loss of symptoms was associated with radiological regression of the ulcer. To attain this result a solution of 95% ethanol was sprayed (to prevent focal freezing) into an intra-gastric balloon (conforming to the shape of the stomach) at an inflow temperature of -17 to -18° C. and an outflow temperature in the range of -8 to -10° C. for one hour; continuous flow is attained by a special pump cooler. Within an hour or two of treatment the patient was found to eat with relish and could resume a full diet henceforth. It may be that gastric "freezing" is a misnomer, since actual recording of gastric wall temperature has been done only in dogs. Of the variables affecting this — temperature-thickness of bag, rate of inflow, opposition of bag to stomach wall, and weight of subject — the last two are different in human subjects, so that it is distinctly possible that actual freezing of the stomach wall does not occur. In any case there is an effective depression of gastric secretion of hydrochloric acid and pepsin, with little effect on motility, for a variable time period, during which the patient is asymptomatic. The only complication of therapy has been a few instances of the development of a post-freeze gastric ulcer; possibly this can be attributed to actual freezing of a localized area of mucosa having been achieved. Contraindications to the use of gastric "freezing" are duodenal ulcer associated pyloric obstruction and gastric ulcer (where there is a good possibility of the ulcer being malignant and where the procedure is not well tolerated).

Gastric cooling is an older procedure which has been undergoing considerable modification in latter years. Originally done by injecting ice water through a duodenal tube, it now carried out by the same cooling apparatus employed in gastric freezing. Any massive upper gastro-intestinal bleeding — bleeding peptic ulcer, oesophageal varices, acute hemorrhagic gastritis — in which the patient's systemic condition is felt to contraindicate surgery or for whom surgery is not indicated is a possible candidate for this procedure. It is probably a less traumatic alternative to the Blakemore tube for oesophageal varices. A stomach-shaped bag is not required for cooling. The one used for gastric and duodenal bleeding is vaguely pear-shaped, while the bag for oesophageal hemorrhage is pear-shaped with an elongated neck so that it can be snugged up against the gastric-oesophageal junction. Before passing the cooling tube, a nasogastric tube is inserted in order to lavage the stomach, since it has been found that blood provides a remarkable insulating effect for the stomach wall The tube is left down throughout cooling, in order to assess the effectiveness of hemostasis and to permit rapid aspiration of alcohol if the bag should rupture. The inflow temperature of the coolant is 4-10° C., which produces a gastric wall temperature somewhere in the range of 20-30° C; temperatures in this range usually effect hemostasis in a few hours, although one exceptional case required cooling for five days. The mechanisms postulated to bring about the cessation of hemorrhage are:

1. Decreased temperature produces vascular constriction;

2. Decreased gastric enzymes (which may have been a contributing factor in the etiology of the bleeding);

3. Tamponade (a minor effect, only occurring in the stomach).

In the interests of economics Doctors N. T McPhedran, R. D. Henderson and A. Gross of the Toronto General Hospital have developed a gastric cooling apparatus which costs a total of fifteen dollars (the regular machines average eighteen hundred dollars). The plastic inflow tube is connected to a cold water tap and passes through the sink which is filled with ice water, achieving an inflow temperature of approximately 16° C. The gastric bag is a condom which produces efficient cooling because of its thin wall. Rate of flow is controlled by a blood pressure cuff gauge, while the intra-condom pressure is measured

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Medicine and Air Transport

G. Harpur 614

Everyone is well aware of the constantly increasing volume of air passenger traffic. In this brief article it is proposed to examine some of the more important problems and limitations of this mode of travel, with special reference given to their medical application.

A list of the more common problems would include:

(1) Weight
(2) Space
(3) Air pressure
(4) Expansion of gases
(5) Noise
(6) Gravitational forces
(7) Motion sickness

Weight

In air travel, weight is an obvious limitation. Aside from the inconvenience of restriction on personal luggage and equipment it has no direct bearing as a medical problem. The one important indirect factor is due to the strict limit imposed on the total pay load by the available lift of the specific aircraft design. This limits the amount of auxiliary and emergency equipment which can be carried.

Space

The close proximity of passenger and crew in the limited space of an aircraft cabin make effective ventilation a must. However, at high altitudes two different problems arise: the first is concerned with maintaining fresh air. Most of the modern aircraft cabins are maintained at a pressure greater than that of the altitude at which they are flying. While losses are kept to a minimum, the average aircraft cabin loses 200 cubic feet of air per minute. To maintain a pressure differential equivalent to 1500 feet altitude with this loss requires an input of 425 cu. feet/min. Therefore, to maintain such a high flow rate, it is essential that most of the ventilating equipment be devoted to the task.

This leaves little more than a minimum of equipment for re-circulation and filtering of cabin air. The capacity of the system can easily be exceeded by strong obnoxious odours which might accumulate within the cabin.

In addition a passenger must be prepared to pay for any additional space he might require as a result of being confined to a stretcher or wheelchair.

The third and fourth factor arise due to the reduction of air pressure as altitude increases. This results in two specific problems: expansion of gases in an enclosed space and reduction in partial pressure of oxygen.

Reduction in the atmospheric pressure surrounding this body will cause expansion of all the gas pockets within it. These include any gas in the respiratory tree, the sinuses, the middle ear, and any which may be trapped in the gastro-intestinal tract. In the normal individual, this expanding gas escapes via the respiratory tree, the eustachian tubes, flatulence and irructation. Often at altitudes of 30,000 feet or greater, several epigastric and abdominal cramps may be experienced due to rapped bubbles in the gut. In addition, a healthy individual can experience toothache due to the presence of minute quantities of air under fillings. Apart from these minor discomforts to a healthy individual, the expansion of trapped air in abnormal sites in the body can have serious consequences.

At an altitude of 18,000 feet, any entrapped volume of gas will either double its size or be exerting a pressure of 380 mm. Hg. against the walls of the cavity. The changes which may result in a therapeutic or pathologic pneumothorax could prove fatal due to respiratory embarrassment or severe mediastinal shift causing cardiovascular collapse. Similarly, changes in air injected for contrast X-rays as in A.E.G.s and peri renal insufflations, or air left behind after laparoty can expand with serious consequence.

When descending from altitude, the problem is one of air contracting as the ambient air pressure increases. The principal area of difficulty here is re-entry of air to the middle ear. Air can leave the middle ear much more readily than it can enter due to the anatomical structure of the eustachian tube. Even normal individuals without nasal congestion may have to perform repeated Valsalva manoeuvers during a rapid descent. If there is congestion present, air flow to and from the middle ear may be improved by use of decongestant drops or sprays containing epinephrine, ephedrine, or neosynephrine.

The associated problem of decreasing partial pressure of O_2 (PO_2) is by far a most serious consideration for the majority of people. At sea level, the PO_2 is 158 mm. Hg.; by 10,000 feet it has fallen to 110 mm. Hg.: at 20,000 feet, PO_2 is only 75mm. Hg.

The effects of the decreasing O_2 tension are first appreciated by the average non-acclimatized individual at 9-10,000 feet. It is said that acute anoxia simulates drunkenness, chronic anoxia simulates fatigue. At an altitude of 10,000 feet, symptoms are minimal with impaired performance of skilled tasks, some dimming of vision, fixity of purpose, a decreased appreciation of pain and impaired judgement. These symptoms increase gradually as PO_2 falls. By 15,000 feet they are marked and by 20,000 feet they are incapacitating causing near blindness and deafness, as well as semiconscious or total unconsciousness. With administration of 100% O_2 the ceiling is lifted to 39,000 feet where the ambient pressure is 140 mm. Hg. giving an alveolar PO_2 of 140 mm. Hg. — 47 mm. Hg. the partial pressure of the water vapour present, or 93 mm. Hg. This PO_2 is roughly equivalent to that encountered at 10,000 feet without a mask. Any further increase in ceiling can only be made by either breathing O_2 under positive pressure or using a pressurized cabin.

Due to the prohibitive cost and the inconvenience of individual O_2 masks for passengers, the aircraft industry uses pressurized cabins. This term merely means that while the ambient pressure at 35,000 feet is 176 mm. Hg. the pressure within in the cabin of an aircraft flying at this altitude is maintained at a pressure of greater than 600 mm. Hg. As this is the ambient air pressure at 8,000 feet, the cabin is said to have an altitude of 8,000 feet. While convenient, this method is not without risks. Equipment failure or a large leak in the cabin wall can result in rapid loss of cabin pressure. Even when expected, a rapid "explosive" decompression is a startling event and certainly a panic situation would result. There is a loud bang followed by a gust of wind, a sudden chill, and a dense mist which takes several minutes to revaporize. Most important, the PO_2 falls rapidly to that of the ambient air. At 25,000 feet everyone would be overcome by fulminating anoxia in one minute. The extent of damage and its reversibility vary directly as the product of the duration and degree of anoxia. The aircraft industry attempts to prevent such occurrences by two methods:

(1) By improved structural material and design. Some examples are double windows and increased compressor capacity.

(2) Provision of emergency oxygen equipment such as face masks which drop down from the ceiling when the cabin altitude exceeds 10,000 feet.

Such action as immediate descent of aircraft to lower, safer altitudes is not without considerable hazard to ears of crew and passengers. They must be instructed to do repeated Valsalva manoeuvers. To ensure that the crew are not overcome by anoxia, the pilots must have their oxygen masks close at hand when the ship is at an altitude in excess of 8,000 feet.

Decompression can occur gradually with small leaks. The hazard is less here because the pilot receives early warning and can bring the aircraft to a safer altitude before effects of anoxia are appreciated. Fortunately, decompression, either slowly or explosively, is not a common occurrence.

With widespread use of insulating materials noise is only hazardous to ground crews. Civilian aircraft are rarely called on to manoeuver so quickly as to significantly alter the G force.

Modern aircraft design and advanced weather forecasting have combined to make air flight most comfortable; however, there are still passengers who suffer from air-sickness. Possible factors are apprehension, vertibular upset with changes in pressure and some burst of motion. Judicious pre-flight sedation may be helpful here.

The above problems may affect the healthy as well as the physically ill person. However, there are specific problems and illnesses which may be affected directly by air transport. Any physician could be asked for pre-flight advice or opinions on these.

Space limits air travel if passengers are on a bed or special appliance. One company permits the purchase of four "seats" in the aircraft to accommodate one stretcher case.

The confined spaces of a (commercial passenger aircraft) will necessarily prevent persons with infectious diseases from travelling.

Patients with pneumothorax, recent AEG, severe sinus congestion or severe head cold may be ill advised to travel by air.

The degree of anoxia encountered at maximum cabin altitude of 8,000 feet may prove too great for:

(1) Patients with Hb of less than 60%.

(2) Patients with arteriosclerotic heart disease — especially within three months of myocardial infarction, or if significant angina pectoris present.

(3) Any patient with impaired pulmonary function resulting in decreased arterial O_2 saturation such as, chest wall injury, emphysema, asthma, or pneumonia.

(4) Any patient with cardiovascular disease which results in reduced O_2 supply to tissues by reason of reduced cardiac output, i.e. conjestive heart failure, valvular disease or congenital heart defects.

(See page 204)

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